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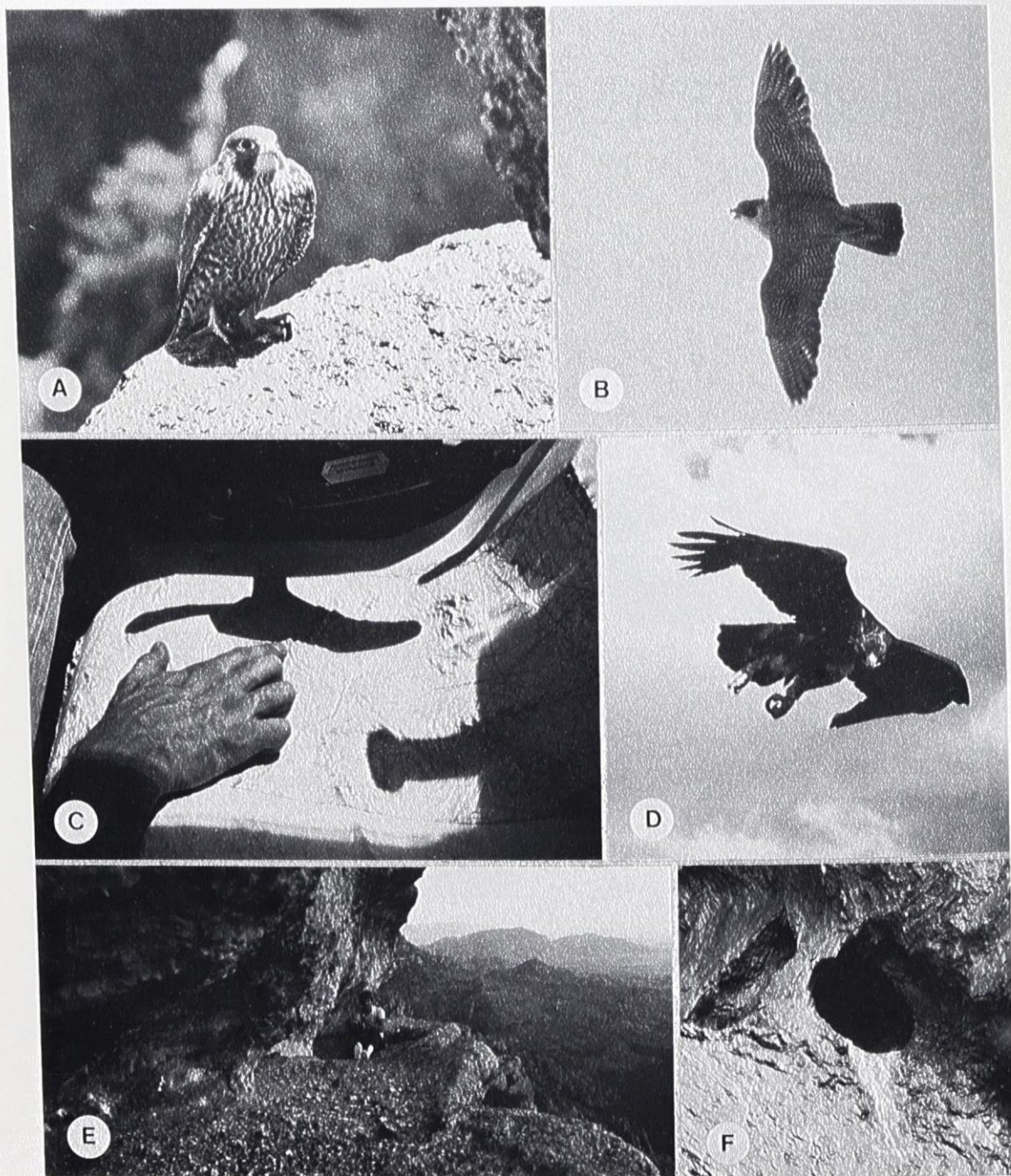


THE PEREGRINE FALCON IN ARIZONA: HABITAT UTILIZATION AND MANAGEMENT RECOMMENDATIONS

by
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No. 1



FRONTISPIECE. A, fledged juvenile at the breeding cliff. B, an adult, typical of Arizona birds. C, key topographic features are identified during the aerial surveys using "raised relief" maps. D, a trained golden eagle was used to attract resident raptors. E, an ideal eyrie ledge: long, broad, and with a low ceiling. F, a pothole eyrie used by peregrine and prairie falcons.

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INTRODUCTION

North American peregrine falcon (*Falco peregrinus anatum*) populations began to decline shortly after World War II. Within two decades the bird was nearly gone from the eastern half of the United States. Joseph Hickey (1970) predicted that the *anatum* race was "certainly" doomed. In the early 1970s single birds were observed at a few locations in the Midwest (Fuller 1976) and Vermont (Temple and Spofford 1976). These were the last wild *anatum* peregrines seen at breeding cliffs in the United States east of the Mississippi River. In the West, perhaps because of less intensive pesticide use, or perhaps because the falcons or their prey are less migratory, a few populations, although much reduced, persisted to the present (Fyfe et al. 1976, Enderson and Craig 1974, Porter et al. 1978).

The reduction of peregrine falcon populations in recent decades provides a unique opportunity to study the habitat preferences of the bird. If it is assumed that, with two decades of population depression, the sites which remain occupied are those most favored by the falcon, then a comparison of the recently active sites with the old sites which are now vacant should aid in identifying some important habitat preference characteristics. This approach is an extension of Hickey's (1942) "ecological magnet" concept. He asserted that the most favored, and therefore the most tenaciously held, sites in the eastern United States had certain common features such as long, high cliffs, close proximity to water, and high topographic relief (Fig. 1). The ecological magnet concept was disputed by Bond (1946) for California and by Cade (1960) for Alaska but the data for Arizona support Hickey's hypothesis.

In Arizona there are now 48 specific locations where information is sufficient to conclude that peregrine falcons probably or surely bred and another 20 general locations where birds likely bred in the

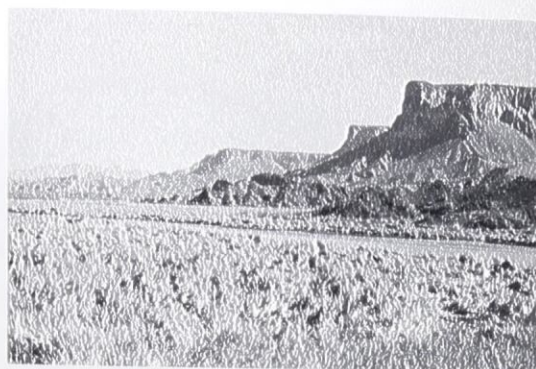


FIGURE 1.—An early peregrine falcon summering area with tall, extensive cliffs and a broad marsh.

vicinity. These figures compare with 94 unknown or probable breeding sites for California (Herman et al. 1970) and 39 for Utah (Porter and White 1973). Before the decline during the pesticide era there were likely in excess of 100 breeding pairs. Most of the old historic sites are now unoccupied (Ellis 1976), but there is a substantial nucleus of breeding adults (over 20 pairs) widely scattered across the state (Ellis et al. 1982).

The first objective of this study was to describe falcon breeding sites in quest of habitat preference trends which could be quantified and developed into a habitat evaluation model to identify suitable peregrine falcon habitat all across Arizona. Next the model was tested by ground searches to determine if falcons could be found at high ranking sites. Although the approach taken in this study is applicable to other areas, the important factors used by peregrine falcons in selecting breeding sites will likely vary from region to region, according to the type and concentration of prey, the topography, meteorological factors, the presence of competing species, etc.

The final objective was to provide recommendations for the wise management of historic and likely falcon habitat.

ACKNOWLEDGEMENTS

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The following people provided helpful background information on the peregrine falcon in Arizona: R. Balda, H. Barker, D. E. Brown, S. R. Carothers, C. R. Darling, J. Enderson, D. Fenske, R. Glinski, J. Hall, G. Huschle, R. R. Johnson, C. Kennedy, J. and S. Levy, J. T. Marshall, Jr., G. McCoard, A. R. Phillips, D. Prentice, J. Schnell, J. Sharber, H. Snyder, W. R. Spofford, L. Stevens, J. P. Taggart, III, C. M. White, and E. O. Willis. Gale Monson provided many summer and winter records.

Many friends and associates have, through the years, assisted in the field and have my thanks. Special credit is due Greg Depner, Jim Fackler, Jay Schnell and Larry Stephens, all of whom worked far in excess of their reimbursed time. Rich Glinski generously served as pilot in the 1978, 1979 and 1982 aerial surveys. Ed Olson coordinated Bureau of Indian Affairs and Navajo Tribal support for the project. Ray C. Erickson and Jack Woody arranged for Fish and Wildlife Service support during early phases of the project. David R. Patton, Project Leader for Wildlife Habitat Research at the Station's Forestry Sciences Laboratory in Tempe, and Teryl G. Grubb, Wildlife Biologist also at the Tempe office, coordinated research funding through the Station. I also express appreciation to Chuck Kennedy, Don Siebert and Ed Olson for arranging support through their agencies. James Enderson and Jerry Craig provided reviews of an early version of the text. For help in preparing several versions of the report I especially thank my wife Cathy.

Without the help of those listed above, this project could not have been completed. I express to all my grateful appreciation.

METHODS

The approach was first, to document as many as possible early breeding sites in Arizona; second, to locate a significant number of recent sites; third, to compare the physical differences between the two groups; and fourth, from the comparisons, to identify factors which are common to all sites and factors in which the recent sites differ from the long inactive early sites. The habitat preference factors were then collated into a descriptive model and used to evaluate cliff zones all across Arizona. The accuracy of the model was tested by determining if, as new eyries were located, they occurred at predicted spots. The model was further refined as new eyries were found and was subjected to further testing on the Navajo Indian Reservation in 1982.

The first phase of the project began in 1974. A review of the published literature revealed many references to peregrine observations but very few references to breeding. A search of agency files resulted in a few more records, but more valuable was a personal contact survey of nearly 100 persons suspected of having knowledge of the peregrine in Arizona (Table 1).

All of the sites thus located were visited on the ground and habitat parameters listed in Table 2 were measured. For sites where the exact eyrie was known, measurements were made on the size and placement of the breeding shelf. Cliff heights were measured directly (using ropes) or approximated by comparing topographic maps, aerial and ground oblique photographs, and measurements from a small transit. Because of the arbitrary nature of some measurements (e.g., deciding on the exact elevation of the rim of the breeding cliff) and because some measurements are approximations, all measurements were rounded to significant figures. All estimated values are believed to be within 10 percent of their true value.

Because the goal in this report was not

TABLE 1
Sources for forty-eight peregrine falcon breeding records for Arizona¹

Site Classification ²	Number found by each method			
	Literature	Agency files	Personal contacts	Fieldwork
Known	4	1	10	17
Probable	1	5	11	3
TOTAL	5	6	21	20

¹Sites from more than one type of source are included in the table more than once, hence an overall total of 52. Records are available for over 50 additional summering sites where information is insufficient to conclude breeding. Only those sites are included in the analyses for which the breeding cliff was in Arizona or near enough to the border to expect that hunting adults and dependent young regularly visit the State.

²Sites were classified as follows: Known = locations where eggs, nestlings, or recently fledged young have been reported by a competent, reliable observer. Probable = locations where, during the breeding season, competent, reliable observers reported at least: (1) two observations of a pair of adults attending a specific cliff, or (2) one observation of an adult calling and stooping at an intruding human near a suitable nesting site.

TABLE 2
Breeding site description parameters

- | | |
|------|---|
| I. | Topography |
| A. | Elevation ¹ |
| 1. | at cliff rim |
| 2. | at high point (r=2 mi) |
| 3. | at low point (r=2 mi) |
| 4. | total topographic relief (No. 2 minus No. 3) |
| B. | Cliff |
| 1. | Height ^{1,2} |
| 2. | Verticality ² |
| 3. | Extent of suitable cliff (r=2 mi and r=0.6 mi) |
| 4. | Directional exposure ¹ |
| 5. | Was tallest cliff used (r=2 mi)? |
| 6. | Was most elevated cliff (of comparable height) used (r=2 mi)? |
| II. | Vegetation |
| A. | Community at cliff base, at cliff top, at nearest water |
| B. | Predominant community in circle (r=2 mi) |
| III. | Hydrology |
| A. | Annual precipitation ³ |
| B. | Type, extent, and distance of nearest surface water |
| C. | Type, extent, and distance of alternate source |
| IV. | Prey |
| A. | Probably hunting areas |
| B. | Most probable prey |
| 1. | species |
| 2. | abundance |
| 3. | proximity |
| V. | Administration (or ownership) of site |
| A. | Cliff |
| B. | Near environs |

¹Approximated from USGS topographic maps compared with aerial and terrestrial oblique photographs.

²Measured with pocket-transit and compared with approximations of the site made as described in footnote 1.

³Precipitation zones from U.S. Weather Bureau maps for Arizona.

to describe the average eyrie but rather to identify the range of suitability for each quantified habitat characteristic, emphasis in the text is given to ranges and extreme values. The site description data are provided in Appendix I.

After the historic sites were visited and evaluated, the next phase was to locate potential sites and check them for occupancy. From 1975 to 1977 potential sites were identified while traveling to historic eyries and, more important, during preliminary aerial surveys. In 1977 a rough habitat evaluation model was prepared based on the early sites and the few recently found sites. In constructing the model, the breeding records were divided into two temporal groups. "Early" sites were those known to be occupied only before 1970. "Recent" sites were those with a history of occupancy by a pair of birds after 1969. Presumably most or all recent sites were also active before 1970. January 1970 was chosen as the dividing date because the falcon had declined enough by 1970 (Ellis 1976) to support the assumption that many historic sites were no longer occupied. Fortunately, this dividing date provided for a sufficient number of sites in each temporal group to allow their comparison. The model, refined with the inclusion of the 1977 data, was based on 24 specific breeding sites and 34 more general sites where exact eyrie locations were unknown. The model was modified into a habitat evaluation guide for use in the 1978, 1979, and 1982 aerial surveys. In 1978 and 1979, all of Arizona was flown in fixed wing aircraft (109 hours total). In 1982 the Arizona portions of the Navajo Indian Reservation were re-flown and the survey was extended into Navajo Tribal lands in New Mexico and Utah (15 flight hours). In extremely rugged areas the raised relief versions of the 1:250,000 U.S. Geological Survey maps were used to more accurately locate important topographic features. After each flight, the location data were transferred to new 1:250,000 maps. Subsequent ground visits were made to more than 230 restricted

sites and over 30 extensive areas across Arizona and adjacent tribal lands.

Several methods were used to determine occupancy. In 1975, many sites which were accessible from above were checked by flying a trained golden eagle (*Aquila chrysaetos*) along the rimrock to attract defending falcons. One summering site was located by this means, but the technique was discontinued because of the difficulty of retrieving the eagle after being downed by defending raptors in rugged areas. Occupancy was determined at restricted sites by observing them for 2-6 (usually 4-6) hours from below and preferably with $\frac{5}{8}$ mile of the potential site between March 1 and July 15. Very long cliff lines were checked by a pair of observers hiking or rafting through the area and periodically stopping for 1-2 hours below the most favorable cliffs. By choosing meal times and campsites to allow for longer inspection of key areas, ten new sites were discovered.

Data for the proposed buffer zones (i.e., falcon responses to motor vehicles, hikers, activities of the research team etc.) were gathered incidental to other research activities. Responses to explosions (simulated sonic booms) and nearby aircraft are derived from a related study (Ellis 1981 unpubl.). Opinions on the importance of an illegal harvest of falcons were extracted from the responses to a survey form sent to state and provincial wildlife departments in the United States and Canada and the regional offices of the U.S. Fish and Wildlife Service.

RESULTS AND DISCUSSION

PRESENTATION OF HABITAT PARAMETERS

In Arizona, the peregrine breeds over a tremendous range of environmental conditions. Birds nested in rainfall zones varying from less than 6 to more than 30 inches per year. An elevation range from less than 1,000 feet to nearly 9,000 feet was used. Breeding sites varied from short bluffs in relatively flat terrain

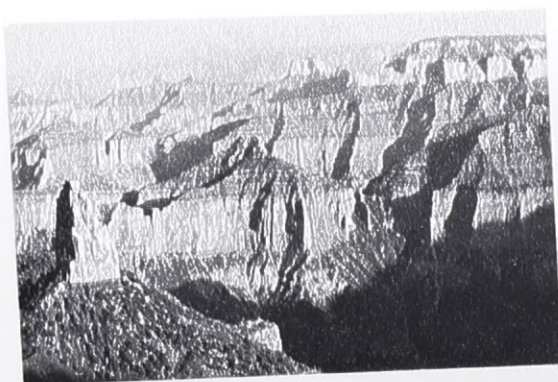


FIGURE 2.—Ideal peregrine falcon habitat: tall, extensive river cliffs in an area of high topographic relief.

to towering walls of rugged mountain canyons (Fig. 2).

Although 58 sites were used to develop the original habitat evaluation guide, only 48 sites, for which data were more complete, were used in the quantitative analysis that follows. Twenty-one of these were located after 1977. In the figures and in Appendix I the number of data points sometimes exceeds 48 because measurements were made, when possible, at more than one breeding cliff used by the falcons in different years.

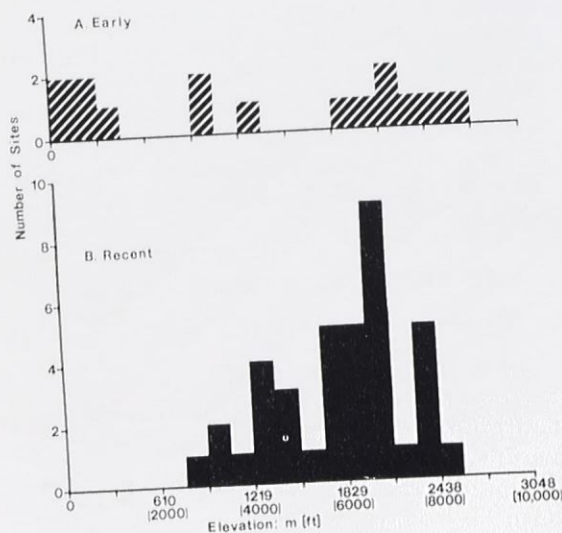


FIGURE 3.—Elevation at cliff rim. For Early sites, $N = 15$. For Recent sites, $N = 37$.

Elevation

In Figure 3 the trends in elevation at cliff rim are presented for early and recent sites. There is no elevational preference shown for the early sites, but a strong peak in the recent site data is exhibited in the 4,000 to 7,000 foot zone. The lack of high altitude breeding sites in either temporal category likely reflects an avoidance of the zone over 9,000 feet as was suggested in the Recovery Plan (USDI, Fish and Wildlife Service 1977). All recent sites and all but two early sites lower than 4,500 feet are closely associated with extensive wetlands (i.e., rivers or lakes) suggesting an avoidance of low elevation breeding sites far from water.

Topographic Relief

Total topographic relief was measured as the vertical distance between the high and low points within 2 miles of the breeding cliff. Prominence was measured as the vertical distance from cliff rim to low point in the same circle. Many sites, both early and recent, are not greatly elevated above the lowlands (Fig. 4). Sixteen recent sites are less than 1,500 feet above the low point. However, there is a strong trend in recent sites toward high total topographic relief (Fig. 5) especially in sites far from surface water. All but one site, with less than 1,000 feet of cliff prominence and less than 2,000 feet of total relief are closely associated with extensive permanent or near-permanent surface water. The single exception is very near an extensive area of marshy springs with a small amount of surface water. At riparian sites it may be advantageous for the falcons to be near the prey supply which is concentrated low over the water or low over a riparian forest canopy. An alternate hypothesis is that the birds nesting low over water achieve some thermal (cooling) or wind current advantage. Whatever the reason two trends are apparent in the data. Near major water sources, birds can be expected to regularly nest low (within 1,000

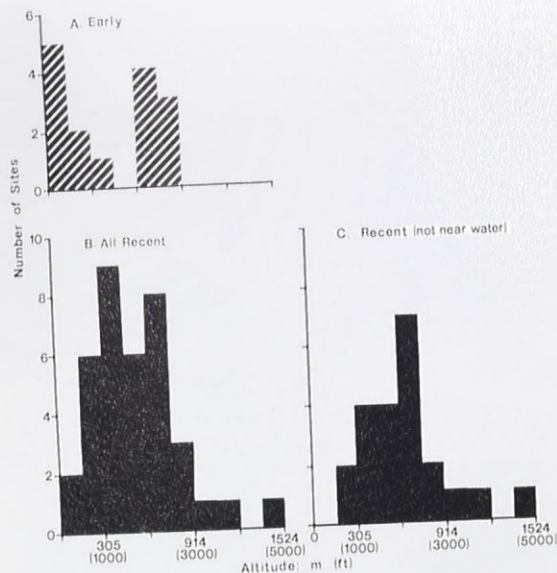


FIGURE 4.—Prominence ($r = 2$ mi): height of cliff rim above low point. For Early sites, $N = 15$. For all Recent sites, $N = 37$. For those Recent sites over 0.3 mile from extensive permanent or near permanent water, $N = 22$.

feet vertically of the low point), whereas far from water, the falcons regularly nest higher. A recent trend toward higher average total topographic relief is apparent in Figure 5.

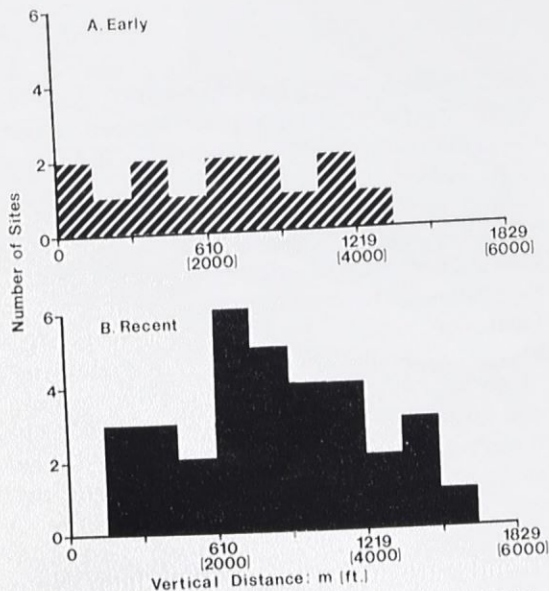


FIGURE 5.—Total topographic relief ($r = 2$ mi). For Early sites, $N = 14$. For Recent sites, $N = 33$.

Cliff Height

In measuring cliff heights, the observer must decide somewhat arbitrarily where the cliff starts and ends. For this study I considered the cliff base to be the highest point achievable by walking when approaching the cliff from below. The cliff rim was the lowest point achievable by walking from above. Many cliffs are divided into layers by broad ledges. Where the ledges could be reached by walking, the topographic feature was considered two cliffs (one of which was measured for height). For example, the shortest recently active cliff is 140 feet but this site actually consisted of a series of cliffs more than 330 feet tall. Because the ledges dividing the series were approachable without climbing, 140 feet was used as the cliff height. If the ledge could only be reached by climbing, the cliff segments above and below the ledge would have been counted together. The only two other recent cliffs shorter than 200 feet were also in this same territory which contained many short but no tall cliffs.

The cliff height data (measured as the elevation difference between cliff rim and cliff base) are very different for early and recent sites (Fig. 6). Recent cliffs average nearly twice as tall (Fig. 7). Most (9 of 14) early sites are cliffs less than 300 feet tall, with low extremes of 50, 60,

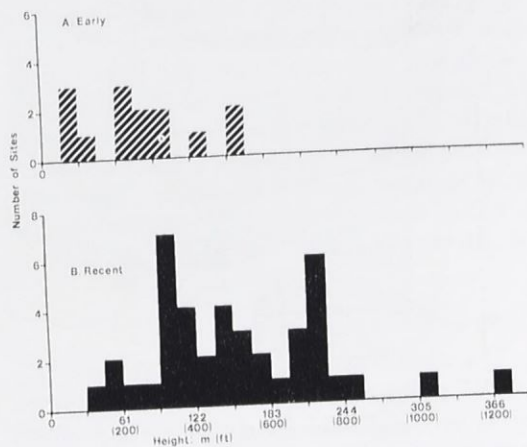


FIGURE 6.—Cliff height. For Early sites, $N = 14$. For Recent sites, $N = 41$.

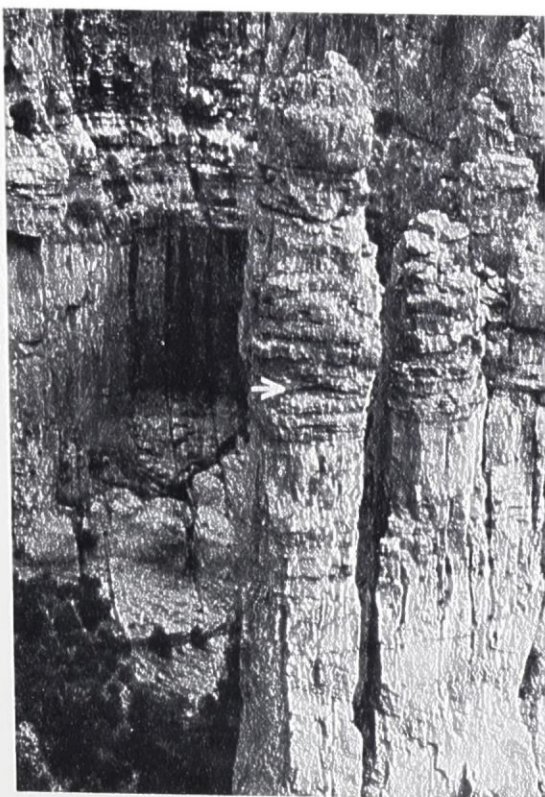


FIGURE 7.—Inaccessible eyrie ledge (arrow) on a 675-foot pillar.

and 75 feet. Cliff height is a useful characteristic separating marginal from fully suitable sites.

Cliff Slope

Of 55 cliffs considered in the analysis, 50 were vertical (80° – 90°) and 5 (2 recent and 3 early) were non-vertical (70° – 80°). At all but one site where the eyrie ledge is known the segment of the cliff immediately above the eyrie was vertical or overhanging. At all sites there was a vertical segment below the eyrie. The three types of non-vertical cliffs encountered in the study are illustrated in Figure 8.

Extent of Suitable Cliff

The recent and early sites differ greatly in the extent of suitable cliffs. Suitable cliffs are defined as those either ≥ 200 feet tall or ≥ 125 feet if lying in a series of layers which total ≥ 250 feet. Two early

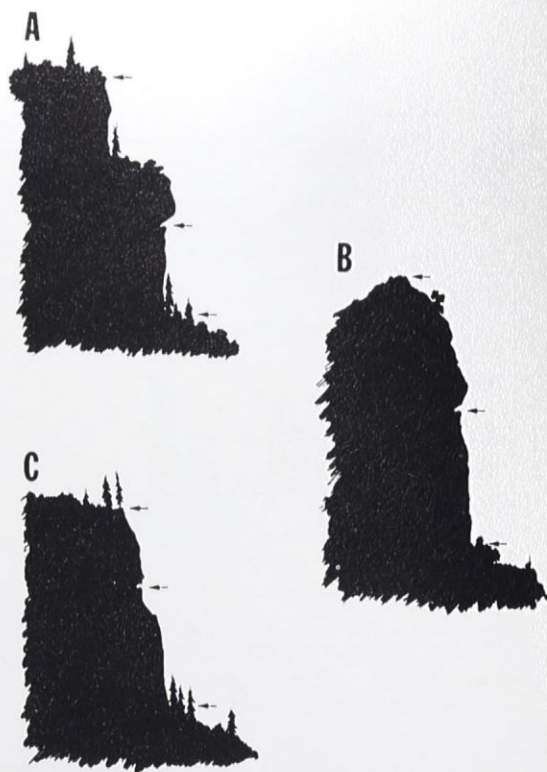


FIGURE 8.—Cross-sections through three types of non-vertical eyrie cliffs. Rim, base and eyrie are at designated levels in each drawing: A, cliffs lying in segments with inaccessible ledges; B, cliffs with inaccessible sloping tops (e.g., pinnacles); C, sloping cliffs with a vertical segment.

sites lacked tall cliffs altogether (Fig. 9). With four exceptions, all recent sites are in zones of extensive suitable cliffs (Fig. 10).

The recent site with the least extent of suitable cliffs illustrates the importance of using a combination of factors in evaluating the suitability of a site. Because the site, when located from the air, appeared exceptionally suitably in terms of topographic relief, vegetative cover, availability of water, and cliff height, it was ranked superior even though there were very few available cliffs. Ground inspection revealed a pair of birds.

Directional Exposure of Breeding Cliffs

Exposure, as treated here, is the general direction which the breeding cliff

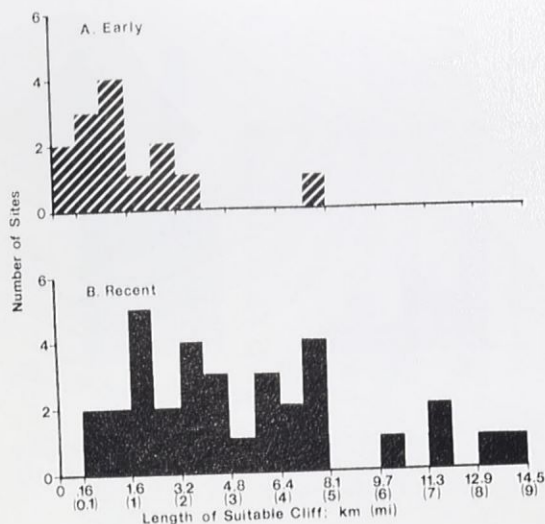


FIGURE 9.—Extent of suitable cliff ($r = 0.6$ mi). For Early sites, $N = 14$. For Recent sites, $N = 33$. Suitable cliffs are defined as those either ≥ 200 feet or ≥ 125 feet if lying in a series of layers which total ≥ 250 feet.

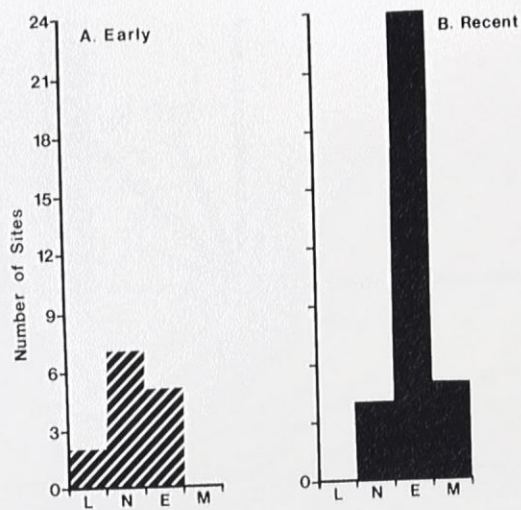


FIGURE 10.—Extent of suitable cliff by classes ($r = 0.6$ mi). For Early sites, $N = 14$. For Recent sites, $N = 33$. Lacking (L): without suitable cliffs; Non-extensive (N): sites with 0.1–0.9 mile of suitable cliffs; Extensive (E): sites with 1.0–4.9 mile of suitable cliffs; Most extensive (M): sites with at least 5.0 mile of suitable cliffs.

faces in the zone near the eyrie but not necessarily the directional exposure of the eyrie ledge. Sites where the eyrie location was not sufficiently known and sites on multifaceted non-extensive cliffs were not included in the analysis. For six sites data for two or three separate breeding cliffs in the same territory are included.

Porter and White (1973) found that the peregrines in Utah most often nested on north and east facing cliffs, presumably for thermal reasons. The data for Arizona show high utilization of north and west facing cliffs, but little use of south facing cliffs (Fig. 11). From the Utah and Arizona data (Fig. 12) it is apparent that peregrines can nest on cliffs facing any direction, even in the warm climate of the southwestern United States. The structure and placement of the eyrie is often more important in determining the degree of insolation than the orientation of the cliff. For example, at the two sites which face south-southeast (and which would likely be insolated most of the day), overhanging ledges provide continual shade for the nestlings (Fig. 7). At

another site, a wall across the canyon shades the west facing eyrie from the mid and late afternoon sun. Some breeding ledges are strewn with boulders and vegetation which also provide shade. Because of the lack of clear directional preferences, cliff orientation alone is of little use in evaluating the suitability of potential breeding sites.

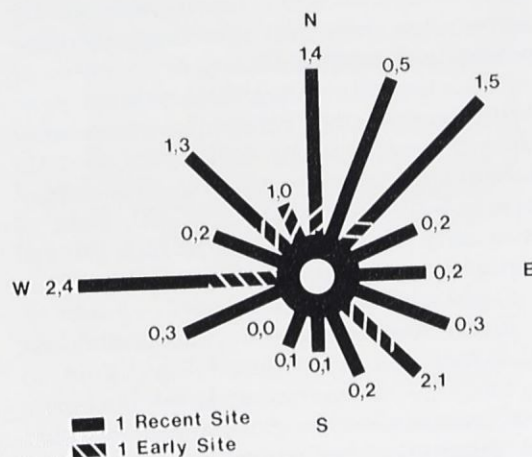


FIGURE 11.—Directional exposure of breeding cliffs in Arizona ($N = 46$).

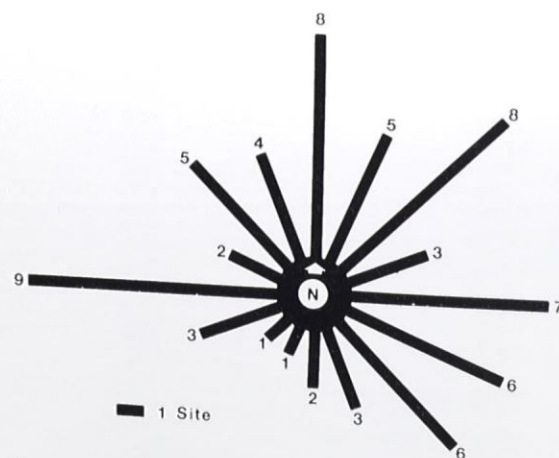


FIGURE 12.—Directional exposure of breeding cliffs in Utah and Arizona (N = 73). Utah data from Porter and White (1973).

Vegetation, Precipitation and Proximity to Surface Water

Three factors—vegetation, precipitation, and the presence of surface water—apparently work together to affect peregrine occupancy. All recent sites are either in wetter zones, have extensive areas of overstory canopy cover, or are near extensive permanent surface water. Some sites lack one or two of the three factors but no recent site and only two early sites lack all three factors.

Breeding sites (early and recent) occur over a broad range of vegetation types from montane coniferous forest to Mohave and Sonoran desert. All recently active sites are either very near extensive permanent surface water, or in areas of not less than 10 inches of rainfall per year. Most recent sites receive more rainfall than the average for early sites, but six recent sites receive only 5 to 10 inches of precipitation annually (Fig. 13). Four of five early sites in the 5 to 10 inch rainfall group are also very near extensive permanent surface water.

Even the driest areas have standing and running water occasionally. Artificial impoundments, natural potholes, and seeps provide permanent or near-permanent water sources over most of Arizona. The water sources used in this treatment are those identified by Brown

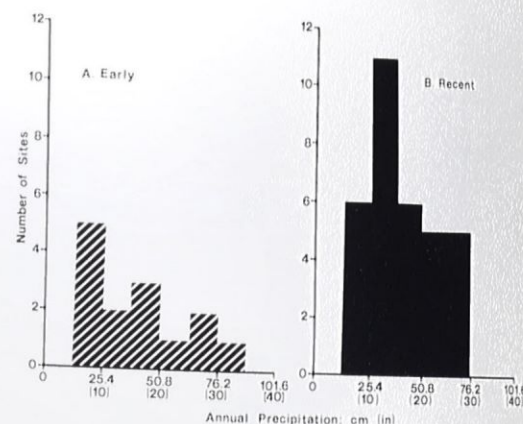


FIGURE 13.—Annual precipitation at breeding sites. Data from U.S. Weather Bureau. For Early sites, N = 14. For Recent sites, N = 33.

et al. (1978) plus a few additional artificial impoundments of known permanence and a few large intermittent streams which during the study have had flow through the falcon breeding season.

The importance of nearby extensive surface water is illustrated in Figure 14. Nearly all of the early and recent sites which are great distances from extensive permanent surface water have near-permanent sources nearby. One recent site, for example, is just above a near-permanent stream and overlooks a reservoir which is wet throughout the breeding season, however, the nearest water of known permanence is 12 miles away. Rivers, lakes, and streams are the most important sources.

Selecting Key Factors for Habitat Evaluation

Three types of key factors surface from the treatment thus far: (1) traits which are common to all breeding sites, (2) minimum values for recent sites, and (3) traits for which trends are very different for early and recent sites.

Traits which are common to all sites include:

1. Elevation less than 9,000 feet.
2. Cliff height 50 feet, or greater.
3. All cliffs approaching vertical and with a vertical segment.

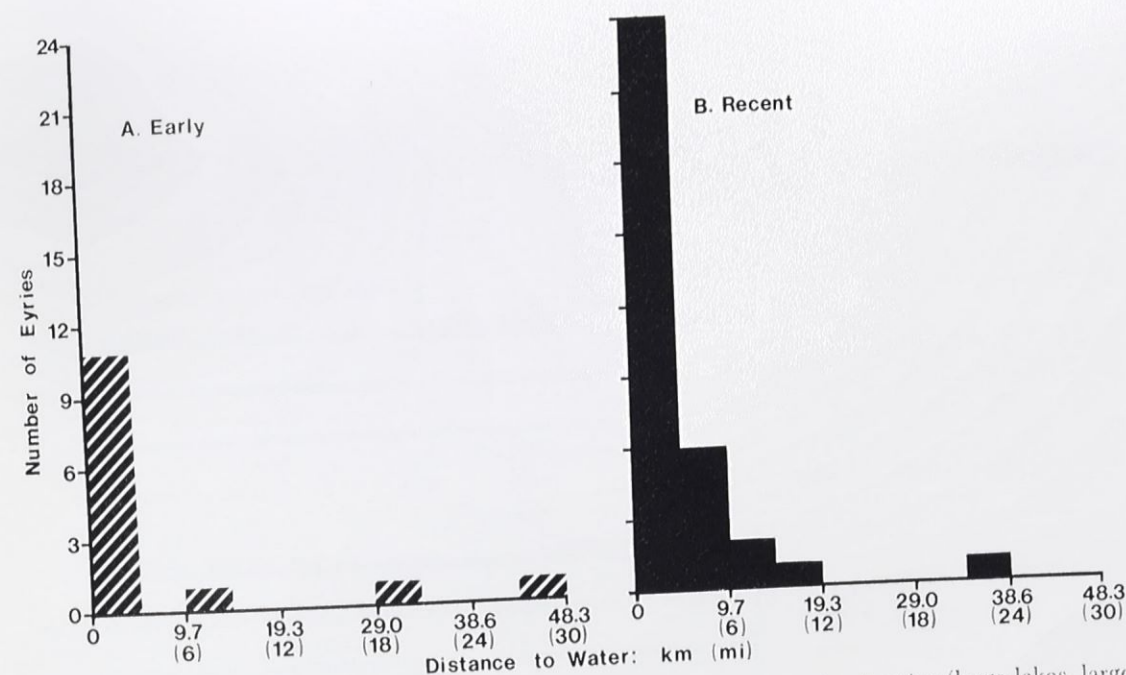


FIGURE 14.—Distance from breeding sites to permanent or near permanent, extensive (large lakes, large streams, rivers, or large marshes) surface water. For Early sites, N = 14. For Recent sites, N = 34.

4. All sites within 6 miles of permanent streams, rivers, or ponds, or associated with mountain ranges and/or canyon systems which have large ephemeral streams.

Minimum values for recent sites include:

1. Cliff relief at least 500 feet above low point within a 2 mile radius, unless very near extensive surface water.
2. Total topographic relief exceeding 900 feet within a 2 mile radius, unless very near extensive surface water.
3. Cliff height either 200 feet or greater, or lying in a series with one layer at least 125 feet tall and the total series at least 250 feet tall.
4. Suitable cliffs at least 0.1 mile in extent within a 0.6 mile radius.
5. Located in extensive mountain ranges or extensive canyon systems.

Comparison of early and recent sites shows the following characteristics:

1. Most recent sites are within a narrower elevation range (between 4,000 feet and 8,000 feet).

2. Recent sites average greater in total topographic relief (usually greater than 2,000 feet within a 2 mile radius).
3. Most recent breeding cliffs are taller (usually over 300 feet tall).
4. Recent sites tend to have a greater extent of suitable cliff (usually greater than 1 mile within a 0.6 mile radius).
5. Most sites (early and recent) are within 3 miles of extensive, permanent, or near-permanent surface water.

DEVELOPING THE HABITAT EVALUATION GUIDE

Four factors showing the greatest potential for defining the breeding niche of the falcon were used to construct a site scoring code (Fig. 15). The full score values for the first three factors (topographic relief, cliff height, and cliff extent) were found by rounding off the value of the recent site in the 40% position. For example, the recent values in total topo-

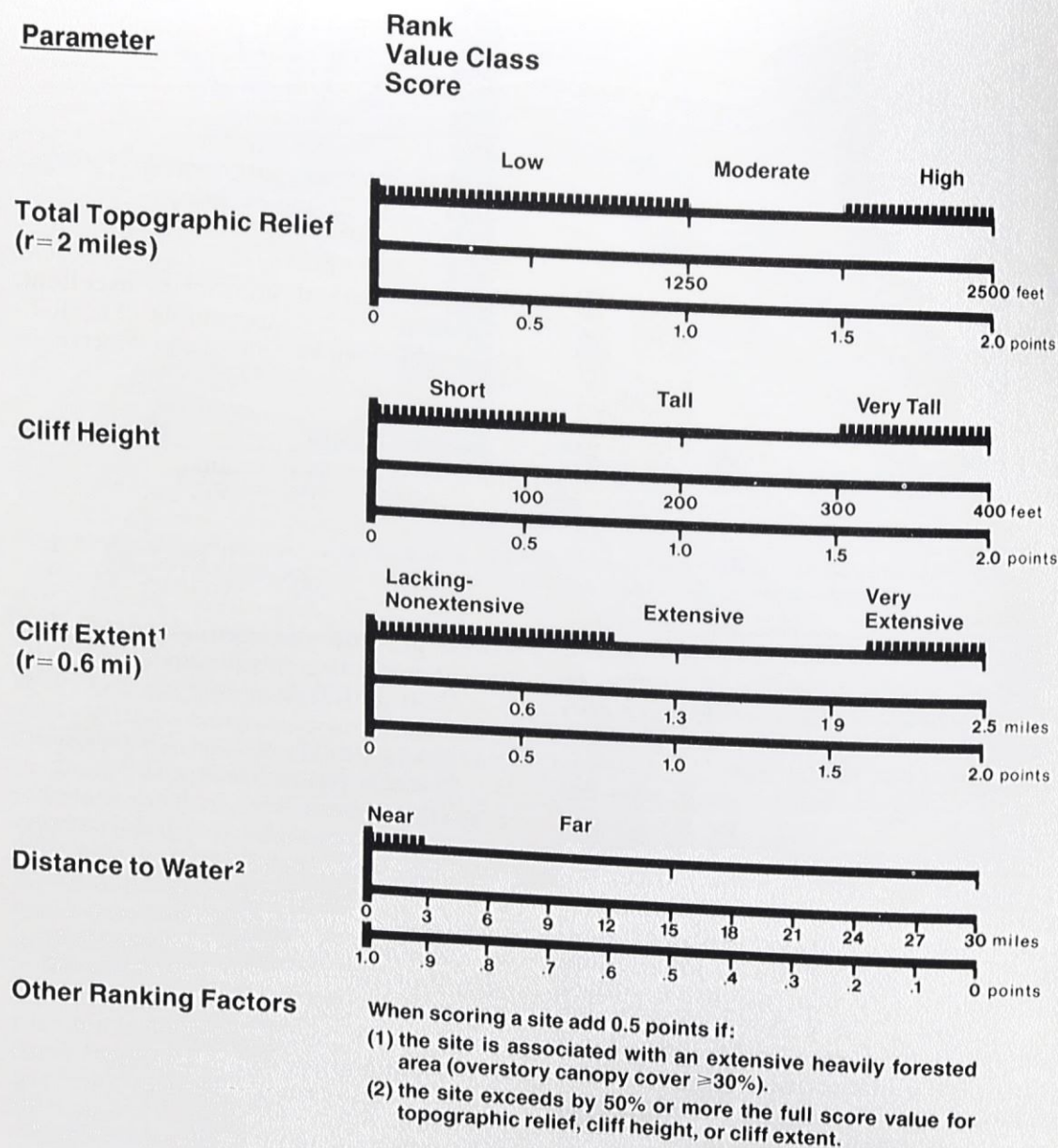


FIGURE 15.—Site Scoring Code.

¹Suitable cliffs are defined in Figure 9.²Distance to nearest extensive permanent or near-permanent surface water.

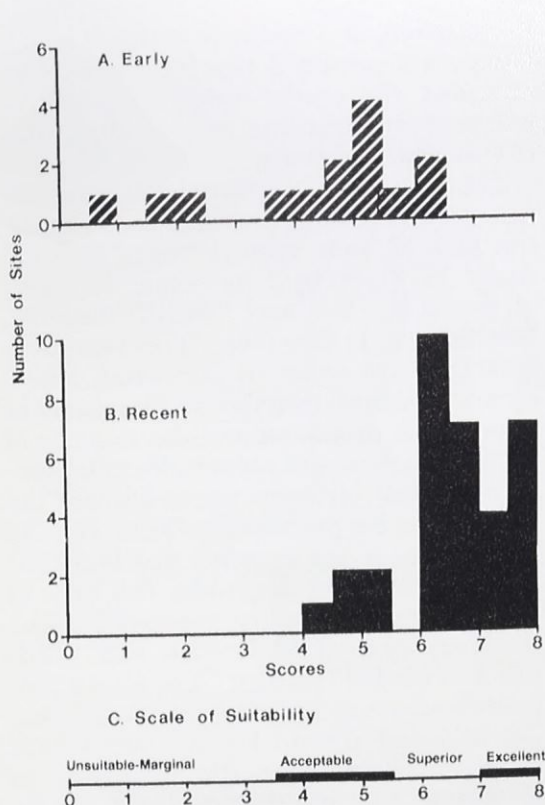


FIGURE 16.—Site evaluation classes. For Early sites, $N = 14$. For Recent sites, $N = 33$.

All sites scored acceptable or better are associated with extensive mountain ranges or extensive canyon systems.

graphic relief varied from 525 and 5,120 feet. The site ranking 13 (40% of 33 sites) had a value of 2,250 feet. For convenience in handling, this value was rounded to 2,500 feet and assigned a full score of 2 points. Handling the data this way (i.e., assigning full score to the 40% site) avoids penalizing sites which provide a sufficiency of a certain trait merely because other sites show this trait to excess. A small bonus (0.5 point), however, was allowed sites which showed one or more factors to excess (Fig. 15). Sites with an extensive area of dense woody vegetation were also given a slight advantage (0.5 point) in the model.

The site scores are illustrated in Figure 16. The zone of overlap (4.0 to 6.5) contains those recent sites which are deficient in some characteristic and those

early sites which are likely candidates for reoccupancy. The site scoring system presented in Figures 15 and 16 was simplified into a habitat evaluation key (Fig. 17) for field use. To test its usefulness in indentifying falcon habitat, an early version of the key was employed in the 1978 and 1979 aerial surveys of cliff zones across Arizona. An updated key was then used in 1982 to complete the evaluation of the Navajo Indian Reservation. In subsequent ground visits 15 of 19 newly discovered eyries were in areas previously ranked superior or excellent. Four were ranked acceptable. The habitat evaluation key proved effective in identifying falcon summering sites. Its real importance, however, lies in its usefulness in identifying and giving importance to areas to be managed for falcon reoccupancy as the population recovers.

MANAGEMENT RECOMMENDATIONS

The general philosophy in wildlife management is to minimize the population limiting factors and to maximize the potential for reproduction and survival (Leopold 1933). Some important negative factors affecting the peregrine falcon include: (1) certain pesticide applications, (2) habitat loss due to surface disturbances such as logging, road building, mining, grazing, and urbanization, (3) recreational use of breeding and wintering sites, and (4) illegal harvesting (either through shooting or the taking of young or eggs). There are also positive measures which can increase falcon numbers in Arizona: (1) creating additional food supplies through habitat management favoring prey species or through providing prey directly (e.g., pigeon (*Columba livia*) lofts near eyries), (2) creating breeding ledges on otherwise suitable cliffs, and (3) directly introducing additional falcons from captivity. In this report some of these possibilities are discussed: those activities are emphasized which are not treated in detail elsewhere in the literature.

Information Management

The confidential treatment of eyrie location information is important to insure the privacy of the remaining pairs. Current falconry regulations prohibit the taking of endangered races of the peregrine, but as populations continue to recover the bird will one day likely be reopened for legal taking. At present the illegal harvest of young birds from Arizona, while largely unknown, is probably small. Only one young bird is known to have illegally been taken from the state in recent years. However, judging by the magnitude of the illegal harvest in Canada and Alaska (see quotes that follow), the Arizona population would likely suffer if eyrie location information is mishandled.

N. M. Simmons (letter of 27 October 1977), Superintendent of Fish and Wildlife Service, Northwest Territories, states: "Enforcement problems are of such a magnitude within this large territory that unfortunately the violator often escapes apprehension. We have reason to suspect that peregrine falcons and gyrfalcons (*Falco rusticolus*) are taken out of the Territories illegally each year. Our prosecution rate for raptorial birds is very low."

LeRoy W. Sowl (letter of 25 October 1977), writing for Gordon W. Watson, Area Director, Fish and Wildlife Service, Anchorage, Alaska, states: "...the biggest (raptor) problem is people coming to Alaska attempting to capture peregrines and gyrfalcons for falconry or sale."

The release of eyrie locations, either through too freely using this information within agencies or through publication (even in scientific reports), is likely to result in increased harassment, not only from falconers (Schilling and Konig 1980), but also from photographers, birders, zoologists, and even wildlife managers (Olsen and Olsen 1978). Because of this danger the National Wildlife Federation, International Association of Fish and Wildlife Agencies, Wilson Ornithological Society, Raptor Research

Foundation, and Southwest Hawk Watch have each adopted resolutions recommending the confidential treatment of information regarding the breeding sites of vulnerable raptors.

There are also economic reasons for carefully handling eyrie location information. Jack H. Berryman (letter of 23 February 1978), Acting Associate Director of the U.S. Fish and Wildlife Service, Washington, D.C. wrote: "This year, over \$300,000 was spent in protecting falcon eyries." Considering the small number of eyries then protected and the number of eyries which would potentially need protection if all locations were known, the cost would be prohibitive. Most sites in Arizona are so inaccessible that logistical considerations alone make the task of protecting them nearly impossible. The recovery plan (USDI, Fish and Wildlife Service 1977) states: "The above protective measure [guarding eyries] is expensive and should be avoided where possible. Generally, the best way to eliminate this need is to limit public knowledge of eyrie sites. Should a particular site become popular, the responsibility of protecting the site should be the responsibility of the appropriate land management agency, the state agency, and the Fish and Wildlife Service."

Where breeding sites remain unknown there is no need to enforce the non-harassment provisions of the Endangered Species Act. Besides expense another drawback of the eyrie warden alternative is that the very act of enforcing non-harassment leads to an increase in the number of persons knowing breeding locations. Eyrie wardens should be considered a last alternative to be used only when other efforts to protect the privacy of the birds have failed.

Limiting Human Disturbance

Unfortunately, peregrine falcons tend to concentrate in winter near waterfowl hunting areas where they can readily be shot. This is, at least locally, an important factor for the peregrine (Enderson 1969, Herren 1969, Lindberg 1975, Snyder and

<u>Surface Water</u>	<u>Cliff Height</u>	<u>Cliff Extent</u>	<u>Total Topo- graphic Relief</u>	<u>Rank</u>
Near Extensive Permanent or Near-Permanent Water	Very Tall	Very Extensive	{ High Moderate Low	Excellent Superior Acceptable
		Extensive	{ High Moderate Low	Superior Superior Acceptable
		Non-extensive	{ High Moderate Low	Superior Acceptable Acceptable
	Tall	Very Extensive	{ High Moderate Low	Superior Acceptable Acceptable
		Extensive	{ High Moderate Low	Superior Acceptable Sub-marginal
		Non-extensive	{ High Moderate Low	Acceptable Acceptable Sub-marginal
	Short			Sub-marginal
	Very Tall	Very Extensive	{ High Moderate Low	Superior Superior Acceptable
		Extensive	{ High Moderate Low	Superior Acceptable Acceptable
		Non-extensive	{ High Moderate Low	Superior Acceptable Unsuitable
Not Near Extensive Permanent or Near-Permanent Water	Tall	Very Extensive	{ High Moderate Low	Superior Acceptable Unsuitable
		Extensive	{ High Moderate Low	Acceptable Acceptable Unsuitable
		Non-extensive	{ High Moderate Low	Acceptable Unsuitable Unsuitable
	Short			Unsuitable

FIGURE 17.—Habitat evaluation key. Ranks of acceptable or better should be assigned only to those sites associated with extensive mountain ranges or extensive canyon systems. Sites showing cliff height, cliff extent, or topographic relief to excess, or sites associated with extensive areas of dense woody vegetation will score slightly higher and should be evaluated according to the Site Scoring Code (Fig. 15).

TABLE 3
Proposed buffer zones around peregrine falcon breeding sites¹

Activity	Width of buffer zones above cliff (mi)	Width of buffer zones below cliff (mi)
Hiking	0.5	0.25
Camping	0.5	0.25
Rock climbing	0.75	0.25
Trail clearing	0.5	0.5
Off-road-vehicle use	1	1
Logging	1	1
Road construction	1	1
Fire control measures	1	1
Controlled burning	1	2
Mining (heavy equipment and/or blasting)	3	3
Building construction	2	2

¹Buffers should be in effect from January 15–October 1 for temporary disturbances. Buffers should be in effect all year for activities which result in long-term alterations (logging, road construction, surface mining, etc.).

Snyder 1975, and Shor 1976). Illegal shooting has been identified as an important decimating factor for other raptor species as well (Spofford 1964, Ellis et al. 1969, White 1974, and Picozzi and Weir 1976).

Enderson (1965) reported that the peregrine at temperate latitudes is "weakly or non-migratory." In Arizona, some peregrines remain near the eyrie at least most of the year. Courtship is actively underway in early March, and adults have been observed at the eyries in mid September. As a result of this very long period of occupancy, potentially disruptive activities near the eyries should be scheduled between October 1 and January 15.

Limiting access to areas heavily used by the falcons will minimize the potential for human disturbance. Hiking and camping can be completely compatible with falcon occupancy if a narrow buffer zone is allowed. Broader buffers are needed for disturbances such as rock climbing and off-road-vehicle use. Where falcons are now nesting in close proximity to humans there is no need to eliminate trails, picnic grounds, etc. except where conflicts exist (i.e., where the birds are disturbed by the human activities). However, further development of such

facilities should be discouraged within the proposed buffer zones (Table 3).

The buffer zone widths, although chosen somewhat arbitrarily for some activities, are derived from incidental observations of the responses of Arizona peregrines to various disturbances near the eyrie. In Arizona, as in New England (Herbert and Herbert 1969), the falcons appear more sensitive to disturbances above the eyries than below, hence wider buffer zones are recommended in Table 3 for some activities above the breeding cliff. Loud noises and activities involving more people should be given wider buffer zones (see also Suter and Jones 1981).

Although White and Sherrod (1973) found that it is often possible to approach nesting falcons with fixed- and rotary-winged aircraft without unduly disturbing the birds, they also reported some adverse effects especially when an aircraft suddenly appears over the cliff top. In a recent study jointly sponsored by the U.S. Air Force and U.S. Fish and Wildlife Service, low-level jet aircraft and sonic booms had minimal effect (other than occasional short term startle responses) on nesting falcons and other raptors (Ellis 1981 unpubl.). However, in populations which are extremely reduced (such as the remnant population in Colorado followed

by Enderson and Craig [1974]), it may be wise to encourage all air traffic (commercial, private and military) to avoid pairs which appear unusually sensitive.

Surface Management

In developing the habitat evaluation guide (Figures 16 and 17) five terms were used in classifying potential breeding sites. "Excellent" sites have no obvious deficiencies. Sites which rank in this category should be given highest priority in falcon management even when they do not have birds. "Superior" sites can regularly be expected to harbor birds. Many "acceptable" sites probably will be occupied once populations recover. "Marginal" sites near extensive water providing prey concentrations will occasionally be occupied once populations recover. Unsuitable-marginal sites far from water will seldom be occupied and are of little importance in peregrine falcon management.

As stated earlier the habitat evaluation guide for Arizona should be applied with caution to other geographic areas. An approach like that used in this study can result in the identification of key traits which determine occupancy in other areas, but the important traits will vary. For example in coastal Alaska, the availability of seabird colonies is likely more important in determining eyrie placement than the total topographic relief, cliff extent, etc.

Land use practices such as grazing, logging, development of roads, controlled burns, fire control measures, and mining should consider the falcon. Suitable buffer zones for activities not listed in Table 3 can be extrapolated from those activities listed. It is advisable to schedule extremely disruptive activities (e.g., blasting and heavy equipment operations outside but near the buffer zones) during the period of reduced occupancy (October 1-January 15).

Pesticide Applications

Pesticide and herbicide application practices should in all cases consider the

falcon. The close association between reproductive failure of peregrine falcons and dietary contamination by some of the chlorinated hydrocarbon pesticides has been sufficiently documented (see Peakall 1976 for a review), that a falcon management program is inconsistent with the use of suspect chemicals.

Productivity Enhancement Measures

In addition to providing for a clean environment, four general means are available for maintaining and even increasing productivity. First the habitat around currently active and high potential sites can be managed for the falcon. Second the number of birds in the wild can be increased by various reintroduction methods (Temple 1978b). The recovery plan (USDI Fish and Wildlife Service 1977) outlines the possible methods for manipulating productivity (e.g., double-clutching, artificial incubation, introducing captive produced nestlings to foster parents of other or the same species). These labor intensive activities (Cade 1978) may not be necessary in Arizona if, as indicated by the high average productivity of active sites, the population decline has ended because a relatively large population is still present (Ellis et al. 1982).

A third enhancement measure, augmenting food supplies, has been largely unattempted. One possibility at some sites in Arizona is to provide an abundant, pesticide free, food supply (e.g., pigeon lofts) near eyries where pairs have repeatedly failed to reproduce. For other sites, where topographic factors appear very suitable but birds are not now found, it occasionally will be possible to encourage waterfowl use of a lake or marsh and thereby provide food for the peregrine.

Fourth, the number of suitable breeding sites can be increased by artificial means. Blasting may be used to provide otherwise prime sites with suitable perching, breeding, and roosting ledges (Fyfe and Armbruster 1977, Boyce et al. 1980). Controlled burning or selective

logging may be used to favor a certain seral plant community.

SUMMARY

The peregrine falcon once bred in significant numbers in Arizona. Good documentation is available for 48 specific breeding sites and an additional 20 general locations. This report, based on the published literature, an extensive personal contact survey, an aerial habitat inventory (over 124 hours air time), and ground visits to over 300 locations, provides information on habitat preferences and management practices which can contribute to the bird's survival.

In seeking to identify the habitat preferences of the falcon, many site description factors were examined. Those traits which appeared common to most recent Arizona sites (and therefore most useful in evaluating habitat) were: elevation less than 9,000 feet, cliffs tall or very tall, cliffs extensive, topographic relief high, and surface water readily available. All recent sites are in extensive canyon systems or in extensive mountain ranges. Using a habitat evaluation key derived from the traits common to known breeding sites, all cliff regions in Arizona and the Navajo Indian Reservation were flown and evaluated for suitability. Nineteen falcon eyries located in subsequent ground visits were all in areas previously ranked acceptable or better.

Many management alternatives are discussed: management of information on breeding sites, habitat preservation, controlling disruptive human activities, and enhancing productivity through the creation of suitable breeding ledges, providing pesticide free prey, or direct reintroductions. Given their privacy (and an increasingly pesticide free environment) the peregrine falcon will likely exist indefinitely in suitable areas across Arizona.

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APPENDIX I

Numerical Values for Figures

Parameter	N	Values	Range	Average
RECENT SITES				
Cliff Elevation (feet)	37	4,800; 7,050; 3,200; 2,880; 3,400; 7,850; 4,700; 5,600; 6,600; 5,525; 6,250; 4,200; 7,700; 5,750; 6,500; 6,000; 6,600; 6,750; 4,500; 6,710; 6,820; 5,300; 6,450; 8,100; 6,800; 6,800; 7,920; 7,920; 7,800; 4,034; 4,450; 6,080; 4080; 3,850; 5,900; 6,300; 5,825	2,880-8,100	5,860
Prominence, r = 2 mi. (feet)	37	3,750; 350; 1,100; 1,450; 4,700; 2,450; 3,050; 1,250; 1,350; 2,000; 2,400; 1,375; 2,650; 1,030; 1,100; 1,500; 950; 2,700; 2,000; 2,000; 2,200; 2,250; 970; 530; 2,860; 675; 1,000; 2,000; 1,920; 1,840; 334; 750; 1,840; 950; 1,950; 1,025; 1,600	350-4,700	1,680
Total Topographic Relief, r = 2 mi. (feet)	33	4,750; 3,750; 3,800; 1,950; 4,000; 2,250; 4,500; 2,500; 2,400; 2,200; 3,650; 3,250; 3,100; 3,200; 2,500; 3,400; 2,730; 4,800; 4,150; 950; 1,250; 2,650; 2,900; 2,150; 1,200; 2,100; 2,022; 1,941; 525; 950; 5,120; 1,400; 3,700	950-5,120	2,780
Cliff Height (feet)	41	350; 700; 700; 300; 500; 650; 700; 500; 700; 675; 425; 475; 140; 425; 475; 450; 345; 225; 300; 575; 600; 650; 340; 450; 350; 790; 350; 390; 280; 335; 700; 1200; 800; 1000; 160; 190; 340; 575; 700; 300; 500	140-1,200	500
Extent of Suitable Cliff, r = 0.6 mi (miles)	33	4.1, 7.2, 4.6, 8.2, 3.6, 8.8, 2.8, 3.1, 4.0, 6.3, 2.3, 1.1, 2.7, 1.9, 1.1, 2.1, 2.2, 0.2, 1.4, 2.4, 3.9, 7.1, 3.5, 0.8, 4.6, 0.9, 1.6, 1.0, 0.2, 2.7, 4.9, 4.6, 1.3	0.2-8.8	3.3
Annual Precipitation (inches)	33	25, 25, 20, 25, 9, 12, 10, 10, 8, 25, 18, 16, 25, 20, 20, 16, 16, 16, 20, 16, 9, 11, 14, 20, 14, 12, 14, 14, 7, 7, 10, 6, 10	6-25	15
Distance to Extensive Permanent or Near Permanent Surface Water (miles)	34	ca 0.6, <0.1, <0.3, <0.3, 1.9, 1.0, <0.3, 3.7, 1.9, 0.1, 0.2, 0.5, 4.0, 7, 0.2, 0.2, 1.2, 3, 0.5, 3.3, 0.2, 0.2, 0.3, <0.3, 8.3, <0.4, 9.4, 3.9, 21, <0.1, <0.1, 3.8, <0.1, <0.3	<0.1-21	2.3
EARLY SITES				
Cliff Elevation (feet)	15	4,000; 1,050; 500; 520; 7,000; 6,850; 7,000; 6,000; 7,700; 8,600; 3,400; 400; 275; 3,300; 8,200	275-8,600	4,320
Prominence, r = 2 mi (feet)	15	650; 75; 50; 650; 2,040; 75; 200; 220; 1,300; 2,700; 2,800; 2,050; 2,100; 2,100; 2,800	50-8,600	1,321
Total Topographic Relief, r = 2 mi (feet)	14	2,050; 636; 400; 2,925; 1,450; 300; 1,650; 1,125; 3,800; 2,225; 4,300; 2,500; 3,750; 3,150	300-4,300	2,162
Cliff Height (feet)	14	200, 60, 50, 400, 300, 75, 200, 120, 200, 325, 500, 250, 275, 500	50-500	247
Extent of Suitable Cliff, r = 0.6 mi (miles)	14	4.5, 2.4, 0, 0.9, 1.9, 0.2, 0, 1.1, 0.8, 0.3, 0.1, 1.6, 0.9, 0.7	0-4.5	1.1
Annual Precipitation (inches)	14	12, 5, 5, 5, 8, 6, 16, 10, 30, 20, 16, 25, 41, 25	5-30	14
Distance to Extensive Permanent or Near Permanent Water (miles)	14	19, <0.1, <0.1, 29, <0.1, <0.1, <0.1, <0.1, 1.4, 8.3, 1.5, 2.5, 2.9, 1.2	<0.1-29	4.7